ZOOGOER

NOVEMBER • DECEMBER 1995

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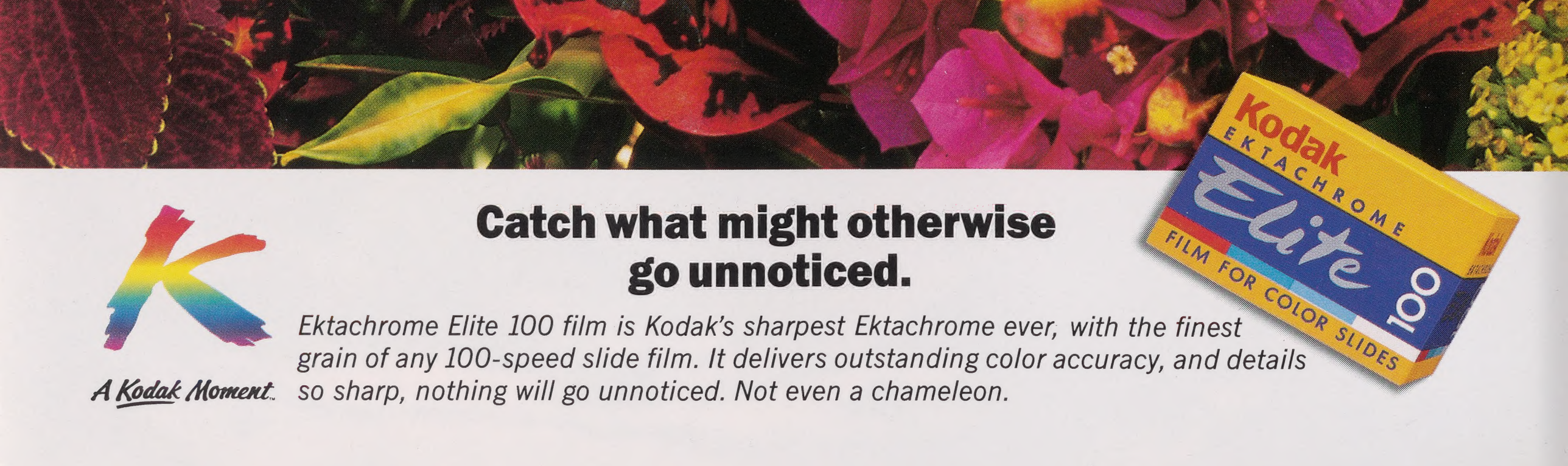

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Rothko? No, Koko. Koko and her companion, Michael, are avid artists. They are also gorillas. This piece is Koko's rendition of a black ceramic cat. For more information about Koko and Michael, write to: The Gorilla Foundation P.O. Box 620–640, Woodside, CA 94062

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Ever wondered if, or how, your cat or dog—or hermit crab—thinks? Now there's a place to piece together some of the mysteries of animal thought. Here's an introduction to the Zoo's new Think Tank, which is not just an exhibit, but the site of scientific studies on animal language, innovation, and society.

Friends of the National Zoo

is a nonprofit organization of individuals, families, and organizations who are interested in helping to maintain the status of the National Zoological Park as one of the world's great zoos, to foster its use for education, research, and recreation, to increase and improve its facilities and collections, and to advance the welfare of its animals.

ZooGoer [ISSN 0163-416X] is published bimonthly by Friends of the National Zoo to promote its aims and programs, and to provide information about FONZ activities to its members, volunteers, and others interested in the purposes of FONZ. Third class mailing permit no. 6282. Copyright 1995, Friends of the National Zoo. All rights reserved.

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Director: Michael H. Robinson.

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Cover: Kiko hangs out on the O–line, the means of transportation for orangs commuting between the Great Ape House and the new Think Tank exhibit. (Jessie Cohen/NZP)

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INTERACTIVE THINK TANK

By now many of you have visited Think Tank, the stunning new exhibit that opened at the Zoo on October 27. It is indeed a great achievement, all the more remarkable for the fact that its opening really represents the beginning of the exhibit not the end. The "infrastructure" of Think Tank—the enclosures, the signs and videos, the O-line—is in place, done. But the core features of the exhibit will continually evolve and change.

Visitors today will see different activities than will visitors next month and next year. The orang utans participating in the language project will learn new "words" and perhaps use them in surprising ways. Other orang utans may fashion and use new tools. The social dynamics of the Sulawesi macaque group will change as babies are born, alliances shift, and dominance ranks rise and fall. And visitors will be able to watch it all, as well as watch the scientists who are studying and documenting the animals' behavior. As Zoo Associate Director and Think Tank project leader Benjamin Beck puts it, "Think Tank is an experiment in which you can participate."

Another aspect that makes Think Tank very unusual among zoo exhibits is that it is about a biological *process*—thinking—rather than about a particular animal species or habitat. It is all the more unusual for two such exhibits to open in one zoo at the same time. The new Pollinarium exhibit, which explores the fascinating process of pollination, is now open, replete with hummingbirds, bees, and butterflies, as well as beautiful plants and creative interactive displays.

FONZ is proud to have helped the Zoo complete these wonderful new exhibits, both of which reflect the Zoo's prominent role at the forefront of innovative exhibitry. Both embody Zoo Director Michael Robinson's vision of the BioPark, which, through our cooperative efforts, is slowly but surely becoming a reality here at the Zoo. And both will inspire the greater appreciation for animals and nature that is so important to the success of conservation efforts. It is indeed an exciting time at the Zoo—and an exciting time to be a Friend of the National Zoo. Thank you for helping to make it so.

Sincerely,

Clinton A. Fields
Executive Director

Jessie Cohen/NZP

notes & news

An Art-rageous Success

Animals and art combined to make the 1995 ZooArts Festival a success. One hundred artists lined Olmsted Walk and occupied booths under a huge tent covering much of the Great Meadow on Saturday, September 30, and Sunday, October 1. The 1994 ZooArts Festival, the first ever, featured 30 artists. This year's event was three times bigger, and was made even more exciting by the presence of six area restaurants serving cuisine from pizzas to Ethiopian food, live bands playing reggae, jazz, world beat, and pan flute music, and Exxon's Tiger Creation Station, which was a big hit with kids. In all, the 1995 ZooArts Festival raised about $25,000 for education programs at the National Zoo.

It's a Zoo at the Mall...

Or at least a Zoo Store, if you're visiting Fair Oaks and Lake Forest malls. There, the FONZ Zoo Stores are now offering up wild ideas for your holiday shopping needs. A menagerie of plush animals awaits the shopper, along with puzzles for all age groups, nature CDs and audio cassettes, animal-themed jewelry, gift mugs, holiday ornaments, African animal carvings, masks, apparel, and much more. The mall Zoo Stores will stay open through mid-January. And, yes, if you're a member, you'll get a FONZ 20-percent discount on any sale.

Dragons on the Move

The National Zoo has been at the forefront of efforts to breed Komodo dragons since the first pair, Friendty and Sobat, arrived as a gift from the Indonesian government in 1988. Since then, 37 young—including the first young to be born outside of Indonesia—have hatched at the Zoo, and at George Mason University, which has been cooperating with the Zoo in its dragon breeding efforts. The Zoo is now spreading the wealth, providing dragons for other zoos around the world as they set up breeding programs. "We're now seeding Europe," said Curator of Herpetology Dale Marcellini. In October, six young dragons were shipped to zoos across the Atlantic: three to Berlin and three to Rotterdam. Four young should soon be shipped to Asian zoos (two to Singapore, two to Japan).

Is Shanthi Pregnant?

Artificial insemination may someday (perhaps very soon) eliminate the stress and cost incurred by transporting elephants between zoos for breeding purposes. To date, artificial insemination has not produced a pregnancy in elephants, despite nearly 20 years of scientific research. On October 2 and 4, Zoo staff, with the help of a visiting researcher and a colleague from the Berlin Institute for Zoo Biology and Wildlife Research, artificially inseminated Shanthi, the Zoo's 19-year-old female Asian elephant, using promising new technology that incorporates ultrasonography to determine the timing of ovulation and to visualize the placement of semen. The semen of a male Asian elephant from the Dickerson Park Zoo in Springfield, Missouri, was collected, processed, and cooled, and then flown to Washington for the insemination the next day. Zoo staff will know if Shanthi is pregnant by the end of December.

To learn more about elephants and the Zoo's efforts to breed them, attend the free symposium "The Science of Managing Elephants: Smithsonian Research and Hope for the Species' Survival," in the Zoo's Education Building auditorium on Thursday, December 7, at 7:30 p.m. For more information, call 202.673.4801, or send an e-mail message to nzpem053@sivm.si.edu.

Mara-velous News

It's been quite a while since visitors have been able to view a baby mara, so the birth of one of these leggy rodents on October 22 was happy news. Maras are large, monogamous rodents that live in arid areas of southern South America. In the wild, they feed on a variety of plants; at the Zoo, these herbivores eat carrots, apples, sweet potatoes, greenbeans, kale, and herbivore pellets.

Jessie Cohen/NZP

Mara mother and her newborn baby.

Get Invited to Zoo Lectures via e-mail

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Think Tank

Machiavellian Monkeys & Shakespearean Apes

The Question of Primate Language

Alex Hawes

The Austrian philosopher Ludwig Wittgenstein once wrote "If a lion could talk, we would not understand him." Of course, he wrote that in German, but we humans have the ability to translate other human languages into ones we can understand. However, as Wittgenstein predicted, translating animal "language" has proven far trickier. Dragging costly sound equipment into the field, scientists have attempted to record animal communication, and then analyze these recordings to determine whether certain species in fact have what can be labeled as language. At the same time, other researchers have focused on the flip side of the coin: whether human languages can be taught to, and understood by, animals, and, if so, how animals would use them.

The notion of animal language sparks furious debate within and between a wide variety of fields: psychology, biology, anthropology, and, as has been noted, philosophy. The linguist Noam Chomsky cites the French philosopher Rene Descartes, who said "the word is the sole sign and certain mark of the presence of thought." Much of the argument over the use of language by animals has ultimately centered on this question: Do animals think? Linguists like Chomsky argue that the basic lack of anything resembling grammar and syntax in animal communication precludes non-human species from higher cognition. Field biologists, however, are quick to counter with evidence of complexities in the way many animal species communicate, not just vocally but with non-verbal signals. All the while, a handful of apes in scientific institutions across the United States are amassing vocabularies of hundreds of words, and using them in ways that challenge our traditional skepticism about the nature of animal thought.

Pensive primate: Tatu, a chimp whose sign language abilities have been studied by Roger and Deborah Fouts of Central Washington University, here gives the sign for "black."

What the Buzz is All About

In the 1920s, an Austrian zoologist named Karl von Frisch embarked upon what became a lifelong passion for spying on bees. He went on to win a Nobel Prize for his discovery and description of the honeybee's food dance, perhaps the most celebrated example of animal communication in the wild. Von Frisch, while at the University of Munich, created special beehives with glass windows, permitting him to look in on the happenings of the hive. What he witnessed

Kenneth Lorenzen

was a system of communication between individual "field worker" bees and the rest of the hive colony so precise that it conveyed the exact location, and desirability, of sources of pollen, nectar, and water, outside of the hive.

Bees live in total darkness while inside the hive. They also are virtually deaf. Therefore, touch, not sight or sound, is the principal sense they rely upon to communicate with other individuals. Worker bees, von Frisch observed, perform either circular or figure-eight dances upon returning to the hive from a find. As it turns out, circular dances communicate to adjacent bees the location of sources of food less than about one hundred yards away. Figure-eight dances, in which bees "waggle" their bodies with varying intensity (causing von Frisch to label the dance "*Schwanteltanzen*," or "waggle-dance"), relay locations over a hundred yards—and up to several miles—from the hive.

Dances are performed on the vertical plane of the interior hive. The angle of the dance relative to the vertical hive wall indicates the angle of the food source in relation to the sun's position in the sky. Dances directed upward mean the food is straight in the direction of the sun, while dances directed downward indicate the opposite direction, with intermediate angles corresponding to change in direction away from this plane. As the day progresses, the angle of the dance for a given location must then adjust to the sun's movement in the sky. The duration of the dance, as well as the total number of "waggles," appears to relate to the specific distance from the hive to the food location, while the "vigor" of the dance communicates the desirability of this food to the hive. The scent from the worker's find serves to define the food source to others.

Not surprisingly, many scientists viewed von Frisch's reports with skepticism. How could insects with such tiny brains communicate with such specificity? Researchers in more recent years have put the bees' abilities to the test. One of the most imaginative efforts was the development of a "mechanical bee," a life-sized, brass robot covered with bee's wax, whose movements and sounds can be controlled remotely. Of course, a bee robot can never be completely lifelike; it cannot, for example, react to the tactile touch of others, and, as a result, often bulldozes into its unamused bee colleagues. Thomas Seeley, a bee expert from Cornell University, half-jokingly estimates the effectiveness of the various robot imposters at about two percent.

However, research employing mechanical bees, as well as other experimental techniques, has enabled scientists to establish the accuracy of bee communication. Though the bees' communicatory system is certainly not perfect, experimenters have found that the insects are generally accurate to within 20 degrees in direction, and within 15 percent of the total distance, in pinpointing a food source's location.

Researchers have also found that honeybee dance is far from automatic. Dancing, rather, is contingent upon the audience. The hive community has a variety of mutual needs, which include a reliable supply of pollen, nectar, and water. Worker field bees can assess the rate of each "commodity" being brought into the hive, and then search for the commodity that seems in short supply. If a bee returns with information about a superfluous food type, it will not perform the location dance. In fact, returning workers do their dance only about 10 percent of the time. "The bee is integrating many variables," Seeley contends. The bee is thinking, one might say.

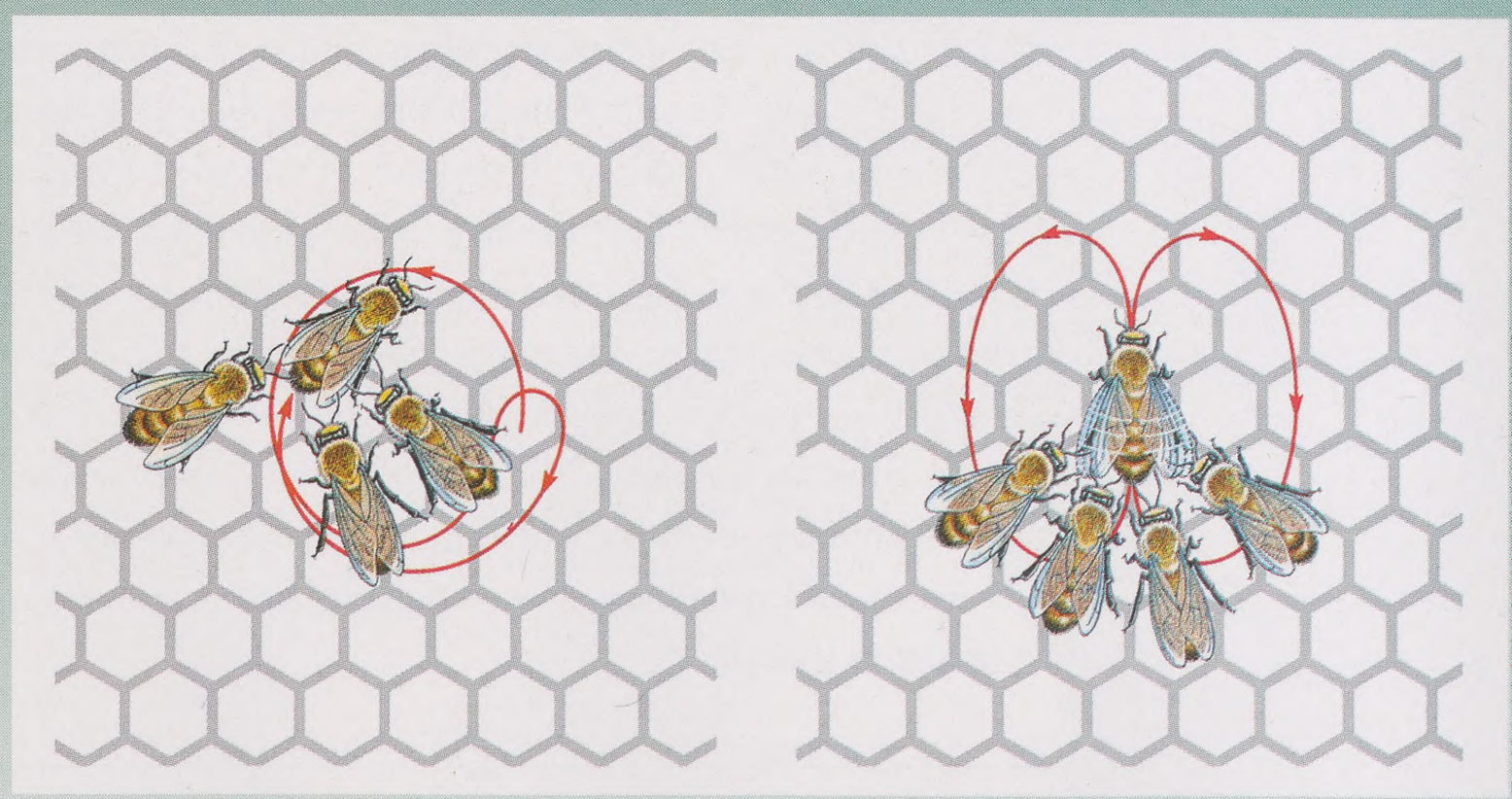
Furthermore, bees in the hive can exert their own decision-making processes upon hearing of food source locations. In one widely discussed anecdote, bee researchers James and Carol Gould performed an experiment in which they presented nectar to several bees in a rowboat in the middle of a lake. The bees returned to the hive with the scent and location of their discovery, but no other workers came back to take advantage of this sugary treasure. Apparently, the bees in the hive had a mental map of their surroundings, on the basis of which they chose to ignore the message. After all, how could there possibly be pollen or nectar in the middle of a lake? (Seeley points out, though, that the bees could conceivably have responded at first, but then turned back at first sight of the lake, unbeknownst to the Goulds in the boat). Yet, as the rowboat was positioned closer and closer to shore, more and more bees appeared in response.

Results from this and other studies indicate both flexibility and intentionality in bee communication—two important indicators of complex cognition (see Mindful of Thought sidebar on page 22). Seeley is quick to caution, however, that there is no syntactical element to this communication, and in that sense it is quite straightforward. "[The notion of] dance-*language* is very misleading," states Seeley. There is also no evidence of learning or teaching in this system; the waggle-dance is seemingly innate.

Bees are nonetheless communicating information while spatially and temporally removed from the food stimulus. In contrast, the highly touted alarm calls of various primates, rodents, and birds (see main article for discussion), despite demonstrating "semantic" object representation, are given immediately, while in sight of the stimulus (the predator).

"Flexible, versatile communication is not a mammalian monopoly," concludes Seeley. Next to humans, honeybees in fact appear superior in their communicatory complexity to all other animals studied by researchers. Quite a stinging indictment indeed.

—Alex Hawes



The Honey Bee, by Gould and Gould. Copyright ©1988 by Scientific American Library. Used with permission of W. H. Freeman and Company.

Left: Honeybee dancing for fellow hive mates. Above: When a food source is near by, bees perform a round dance (left). At greater distances, dances take on a figure-eight shape and incorporate both sounds and waggling (right).

Animal Linguists?

When we think of language, we think of verbs and nouns, tenses and moods. While animals in nature certainly don't have communication systems based on such grammatical ideas, some researchers have suggested that primate "talk" may show evidence of "syntax" and/or "semantics" in a loose sense. "Semantics" refers to the ability of otherwise abstract words to convey meaning, and represent objects and ideas. "Syntax" simply is the ordering of such words along grammatical lines, following rules in word order. For communication to be justifiably considered language, it must contain elements of these linguistic tools, according to many researchers. Furthermore, individuals must use language voluntarily, and communicate information, rather than just emotion. True language, linguists assert, is learned and deliberate, not innate and instinctive.

Bonnie Jay

Scientists have known for years that animals can communicate in often very complex ways. Karl von Frisch, early this century, demonstrated how honeybees, upon finding a source of nectar, can communicate the distance and direction (and even quality) of this source to fellow bees in the hive through a ritualized "waggle-dance" (see sidebar on page 8). As with humans, animals use more than just vocal signals to convey information or emotion. Animals may use body movement, odor, posture, change in color, facial expression, or other gestures to communicate anger, warning, fear, uncertainty, subservience, willingness to mate, and other messages. Does this alone suggest language use? Eugene Morton, an expert on birds, and National Zoo biologist, says no.

"They don't understand and comprehend what they're signalling," argues Morton. He criticizes certain scientists' preoccupation with the content of animal communication ("the Information Impediment," he labels it). Instead, Morton asserts, animals are simply demonstrating motivation through their signals. "[Researchers] have gone overboard in their interpretations," says Morton. In his book, *Animal Talk*, co-written by Jake Page, Morton urges "an understanding of animal communication as what it seems to accomplish, not what it 'symbolizes.'" Morton emphasizes that the use of such communication is innate to animals; they react to stimuli in "pre-programmed" ways, without real thought. Following this argument, while animals may be aware of the ends they seek via signalling, they may not be conscious of the symbolic nature of the means they use to reach those ends. However, many animals, from birds to apes, may have a thing or two to say about that.

Although genetic programming can explain much of animal communication, certain species have shown a remarkable ability to use languages novel to them, either through training or simply through imitation. Parrots, mynahs, and other birds can reproduce literally hundreds of human words. Yet most show no understanding of the words they copy. Some animals, though, seem to have demonstrated a more profound comprehension of human language. Irene Pepperberg of the University of Arizona has worked with an African grey parrot named Alex. Alex apparently is able to "request, refuse, identify, categorize, or

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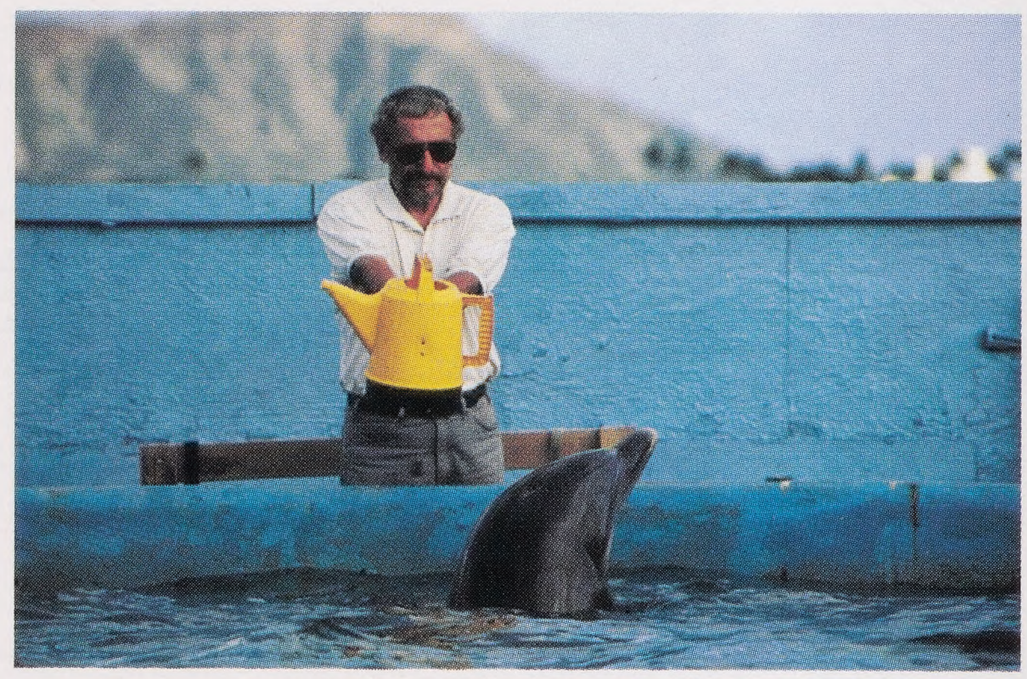
Kyaaro, a young African grey parrot, eating a strawberry. Irene Pepperberg has studied Kyaaro and fellow parrot Alex's ability to name, describe, and even count objects.

quantify" more than 50 items, and label them according to color, shape, and material. He also has learned concepts of sameness and difference. Shown a red triangle and a blue triangle, Alex will say they are same in shape and different in color. Alex uses some syntax, always saying "green wood" not "wood green" for example. However, Pepperberg adds, "Until Alex gives talks for me, it's not really language." Nonetheless, she estimates that grey parrots are on level with a two-and-a-half-year-old human child emotionally, and a five-year-old child cognitively—an important fact to consider before buying one as a pet. "It's like buying a small child," says Pepperberg.

Jessie Cohen/NZP

Louis Herman, of the Kewalo Basin Marine Mammal Laboratory at the University of Hawaii, has studied the responses of dolphins to grammatically structured hand signals. Dolphins trained to respond to commands given in syntax-like order responded with up to 95-percent accuracy, depending on the dolphin and the length of sentence given. They can apply this structure to respond to new combinations of signals. The dolphins studied reject "nonsense" sentences that are improperly ordered.



Ronald Schusterman, of the University of California at Santa Cruz, has worked with a female sea lion named Rocky. As with Louis Herman's tests on the dolphins, Schusterman and fellow UC-Santa Cruz biologist Robert Gisiner taught Rocky a language-like system of signals, and then tested how she responded to unfamiliar combinations. Rocky too could respond to syntactic structures properly after grammar training. The authors emphasize the importance of reinforcement in Rocky's coming to understand the structure of the commands given. Rocky's "language" ability, in their opinion, comes from the "general learning abilities" of animals rather than any innate language comprehension.

L. Herman, 1995

However, it seems reasonable from an evolutionary point of view that if animals can learn a structured language taught by humans, then they must have evolved this ability as a result of there being a selective value of it in the wild. If we accept this reasoning, what then is the adaptive benefit driving complex communication between animals? Most scientists point to one underlying factor: social living. Roger Fouts, the researcher who has studied the sign language abilities of the chimpanzee Washoe

Above left: Sea lions at the National Zoo. Sea lions can learn to understand aspects of human grammar and syntax. Top right: Herman shows watering can to the dolphin Phoenix. Below right: Phoenix then correctly makes a match from a choice of two.

for nearly 30 years, argues that language is primarily a social behavioral mechanism that allows animals to form relationships between one another. "You must form relationships in order to mate," Fouts points out. If you can't do that, then you lose, genetically speaking.

Members of social groups must communicate with each other to relay strategies for foraging or hunting. Information about intentions must be communicated delicately between rival males, lest all encounters result in violence (which often benefits neither one). Communicatory signals may also be used to deceive fellow group members, leading individuals living in social groups to become "natural psychologists" in order to decipher between honest and dishonest signals from others.

However, complex communication does not a language make. Biologists, psychologists, and linguists alike emphasize that language requires rules that guide how signals are combined to relay meaning. Donald R. Griffin, one of the founders of the study of animal cognition, and the author of the book *Animal Minds*, writes that "rule-governed combinations of words convey a much wider array of meanings than would otherwise be possible if each word were entirely independent, and its relationship to the other words did not convey any additional meaning." Few studies of animal communication in the wild have attempted, and even fewer have succeeded, in showing such a rule-bound system in operation among animal societies. Short of proving the existence of such structured arrays of communicative signals, we cannot comfortably say that a given species of animal uses "language."

When Monkey Talks, People Listen

If any animal group shows the traits that might select for language, it is the primates. Members of most primate species live in close-knit, highly structured societies. Group members forage together, alert each other to dangerous predators, and compete with each other for positions in social hierarchies, and for potential mates. Social communication is essential for survival both in a hostile external environment, and a competitive internal society. While primates are not the only animals with these characteristics, they are most closely related to us, and may give us insight into our own communication. Thus, these "Machiavellian" individuals have served as ideal targets for testing the extent to which animals are able to attain language mastery. Hoping to hear what these close relatives of ours can tell us about the nature of their vocal repertoire, researchers have packed up their sound equipment, and gone out into the field to eavesdrop.

R.L. Garner, a biologist with the then newly created National Zoo, set out in 1892 with recently invented recording equipment to capture the speech of primates in the jungles of West Africa. Safe inside a wire-mesh cage for three and a half months, Garner deciphered about 25 to 30 distinct chimp "words." In addition to studying these apes, he also wrote *The Speech of Monkeys*, a book that was decades ahead of its time in investigating the vocalizations, as well as general cognitive abilities, of monkeys.

Since then, technology has advanced, and so has researchers' success in understanding what primates are communicating. Dorothy Cheney and Robert Seyfarth, a husband and wife team from the University of Pennsylvania, are in their third decade of listening to and analyzing the vocalizations made by vervet monkeys (*Cercopithecus aethiops*) in Kenya's Amboseli National Park. Cheney and Seyfarth have spent a great deal of time, it seems, messing with monkeys' minds. Using recordings made of these Amboseli vervets, they have tested how individuals react to playbacks of other vervets' calls.

It is the alarm calls vervets make in reaction to predators that have really gotten the attention of Cheney and Seyfarth. Vervets have different calls for eagles, for leopards (and

First Words

Although studies of animal behavior have revealed astonishing complexities in animal communication, including the capacity for aspects of language in certain species, we humans are the only species with a natural "spoken" language. While apes have been able to learn sign language and other forms of symbolic communication, they are physically incapable of reproducing human speech. The mouth, lips, and tongue—obviously important body parts in the formation of spoken words—are more mobile in humans than apes. We also are able to shape sounds more precisely, because our larynx, or voice box, and our epiglottis (the cartilage that prevents food from going down your windpipe) seem to be perfectly adapted for maximum control of air flow. These anatomical features are unique to humans, although parrots and other birds can mimic human speech with their own specialized vocal apparati. Consequently, attempts to teach apes to talk have failed.

Erik Trinkaus

But when did the evolution of language and speech occur within the hominid lineage? That question has provoked fierce debate among paleoanthropologists and anatomists alike. The soft tissue of the throat does not fossilize, so scientists have not been able to trace directly the evolution of the full range of anatomical traits allowing speech production. Beginning in the 1970s, certain researchers began looking at the bones of the skull, features that indeed can preserve well in the fossil record, in order to find clues to unravel this mystery.

The "flexion" of the base of the skull, the degree to which the floor of the skull is arched relative to the roof of the mouth, has been thought to have important consequences for the orientation of the voice box. The greater the degree of arch in the base of the skull, the lower the position of the larynx in the throat, and, as a result, the greater the ability to produce delicate speech (especially vowel sounds). In most mammals, the larynx, and the rest of the respiratory apparatus, is positioned quite high. While this orientation restricts the range of sounds one can produce, a highly positioned larynx does allow simultaneous swallowing and breathing. Our low larynx thus has its drawbacks (as you may have noticed the last time you tried to talk and eat at the same time). The rearrangement of the respiratory system must have had great adaptive value to outweigh the cost of this increased chance of choking while eating.

Phil Lieberman of Brown University and Jeffrey Laitman of Mount Sinai School of Medicine in New York argue that pre-humans, from the earliest australopithecines to our more recent Neanderthal cousins, did not have a larynx low enough to enable them to speak. Although Neanderthals may have been able to make certain verbal sounds, these "words" were probably very nasalized, which would have interfered with their clarity, and, as a result, their ability to be used in a precise and complex fashion. Only anatomically modern humans, which appear in the fossil record at about 100,000 years ago, seem to have had the necessary "basicranial flexion" (in paleoanthropological jargon) to allow speech, according to the theory's proponents.

However, within the last decade, scientists excavating an archaeological site in Israel, the Kebara Cave, have dug up and analyzed one tiny bone that, they believe, may single-handedly disprove the traditional theory that only modern humans could talk. The structure in question is the hyoid, a horseshoe-shaped bone resting freely in the throat, attached indirectly to the larynx, tongue, and base of the skull by ligaments and muscles. The hyoid is very fragile, and thus rarely found preserved as a fossil, even within relatively recent human remains. Despite decades of excavation at Kebara by researchers from Israel, France, and the United States, "It was a total fluke that this one was found in such excellent condition," according to Lyn Schepartz, a member of the excavation team and a professor of anthropology at the University of Cincinnati. This fossil, dated at 60,000 years old, represents the earliest complete hyoid in the fossil record anywhere in the world. The tiny hyoid may have huge implications for demonstrating the capacity for speech in fossil hominids. It is attached to the muscles controlling the tongue, and its delicate movement within the throat helps control the formulation of speech.

The Kebara hyoid once belonged to an otherwise anonymous Neanderthal individual who roamed coastal Israel during the Middle Paleolithic—at the same time that anatomically modern humans were inhabiting parts of Africa. Schepartz and her Kebara Cave associates argue that this ancient hyoid falls within the range of variation of fully modern human hyoids, both in shape and size, as well as in the way the muscles attached to it. The Kebara hyoid differs markedly in appearance from those of modern great apes. Schepartz and her colleagues doubt the importance of the link between basicranial flexion and the capacity for speech. Their Neanderthal, they claim, could talk.

Department of Anthropology, National Museum of Natural History, Smithsonian Institution

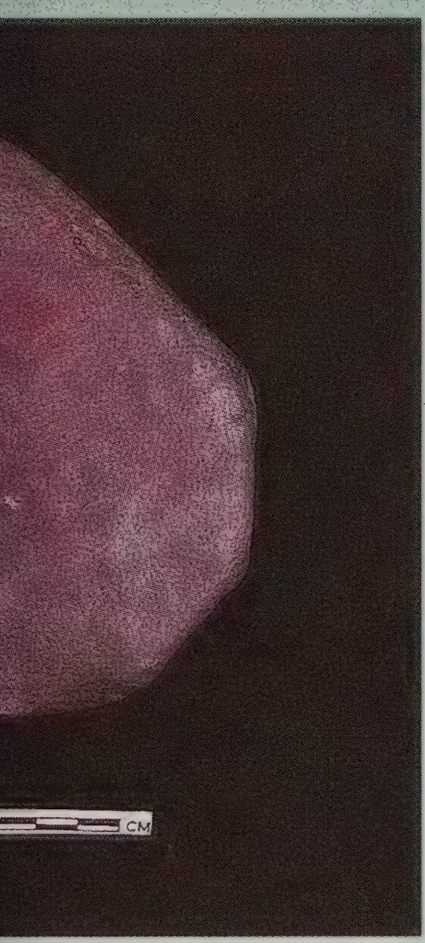
Schepartz faults the "linguicentrism" of researchers like Lieberman and Laitman who stick to their belief in modern humans' unique language abilities. However, Lieberman and Laitman are quick to respond to problems they perceive in the Kebara sci-

Above: 50,000 year-old Neanderthal skull from Iraq. It is unclear whether Neanderthals could speak.
Right: 30,000-year-old stone "palette" from cave in southern France. The stone, smeared with red ochre, is believed to have been used for cave painting, body ornamentation, or object decoration. Evidence for cultural and artistic practices such as these may correspond with the development of highly abstract thought in hominids, and perhaps with spoken language.

entists' line of argument. First of all, they dismiss a theory based on a single fossil find. "You can't tell anything about Kebara," Lieberman asserts. However, without accepting such unique finds (including "Lucy," and other famous discoveries), we would not be very far in our understanding of human evolution.

More important, though, Lieberman and Laitman point to the importance of the position of the hyoid, and the rest of the vocal apparatus, rather than just its size and shape, as indicative of the capability to produce speech. An isolated hyoid, they assert, can tell us nothing about the orientation of the voice box. Infant humans have larynxes placed high in the throat; as a child develops, the larynx gradually descends, physically allowing a child to speak. The shape of the hyoid plays no role in the development of a child's ability to produce spoken words. The Kebara Neanderthal, suggest Lieberman and Laitman, may have had an infant-like laryngeal orientation, and could thus speak only as well as a human infant.

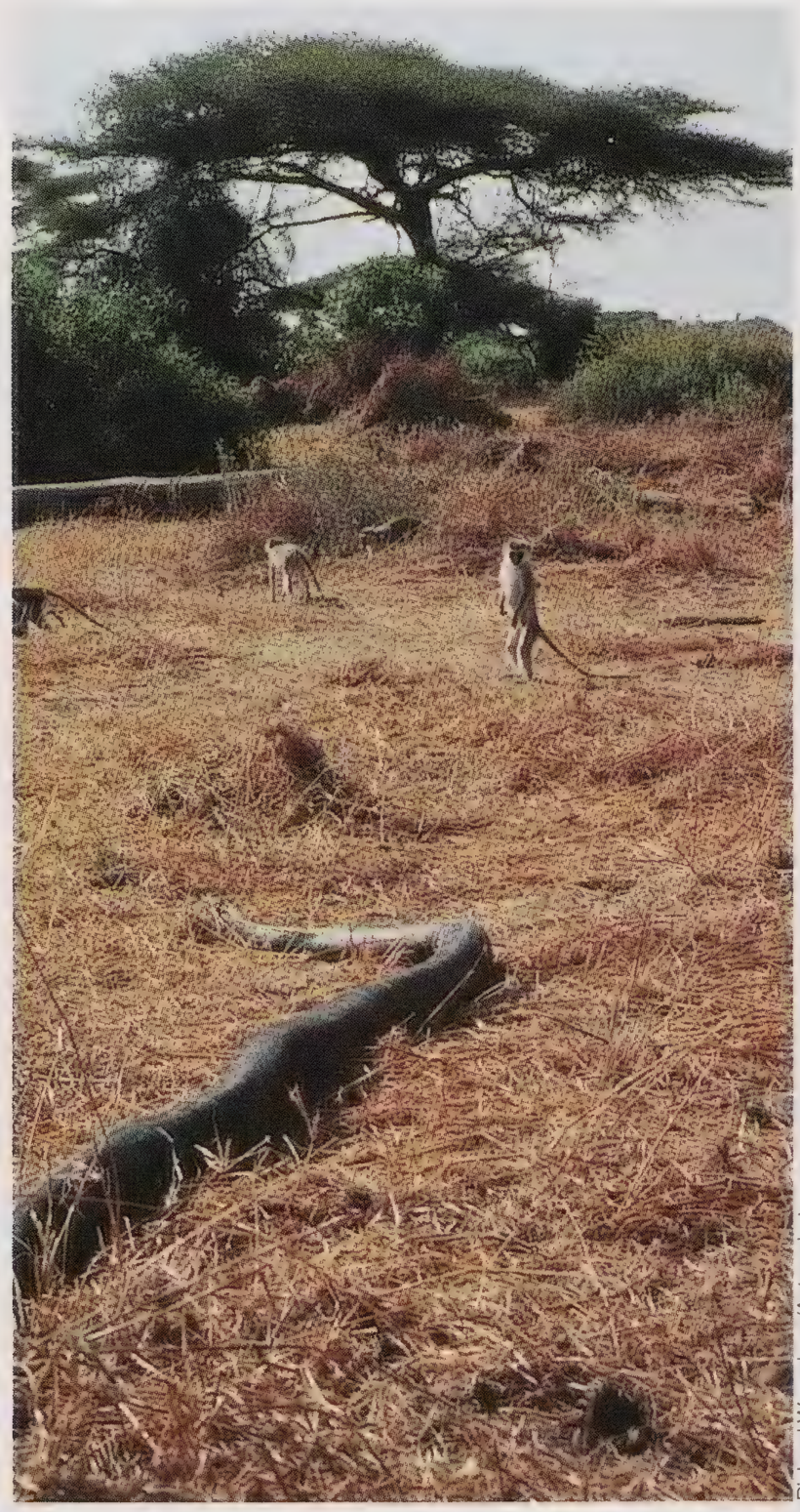
Paleoanthropologists have also looked beyond anatomical evidence in examining this contentious issue. "Language is part of an overall system that involves communication as well as cognition," reminds Schepartz. The cognitive abilities required for speech can also manifest themselves in other aspects of behavior. Some scientists have proposed that remains of statuaries, figurines, cave paintings, and ceremonial burial (though Neanderthals too buried their dead, but in a less ritualized fashion) from within the last 40,000 years indicate that anatomically modern humans alone had the understanding of symbolic expression necessary for spoken language.



Schepartz, however, looks as far back as 300,000 years ago for proof of the division of hominid home sites into areas for hearths, for refuse, and for tool-making, as well as (non-ritualized) burial to demonstrate abstract and complex thought. If we accept this reasoning, Neanderthals, and perhaps even its pre-cursor, *Homo erectus*, had the mental capacity for speech. Exactly which of these cultural practices corresponded with the actual emergence of speech in human evolution is, of course, anyone's guess. Moreover, the ape projects have shown us that, if taught, great apes too have the ability to use language in complex ways. Perhaps speech goes back even farther in the hominid line than we have imagined. If only fossils could talk....

—Alex Hawes

leopard-like predators), and for snakes, each eliciting different behavioral responses from their group. An eagle alarm call sends vervets scrambling down trees to hide in the brush, while leopard calls send them scurrying up into the trees, while snake calls cause the vervets to stand up on their hind legs and survey the area for the intruder. Later research has shown that vervets aren't alone in having differentiated alarms—so do certain other primates (such as lemurs), as well as ground squirrels, prairie dogs, and starlings.


Richard Wrangham/Antro-photo

Vervets also grunt to each other in passing. With the aid of sound spectrographs, Cheney and Seyfarth discovered that what seemed to the naked human ear as only one vocalization actually had quite subtle distinctions. Vervets grunt differently to subordinate individuals, to dominant individuals, to approaching individuals, and to members of other groups.

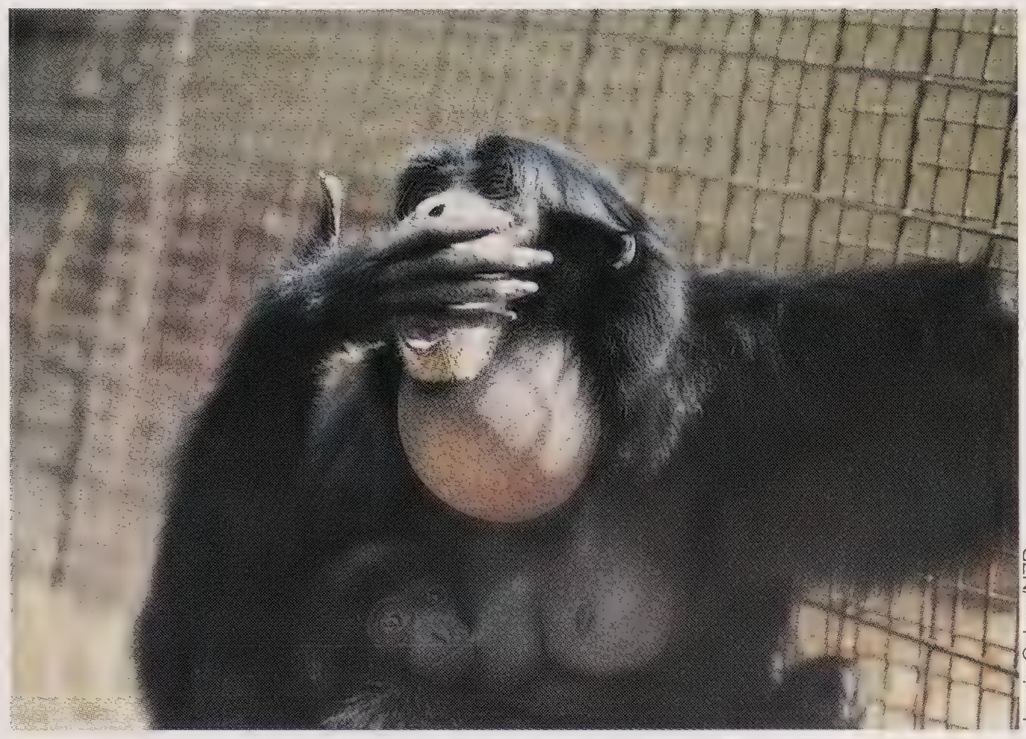
This evidence of vervet alarm calls and grunts has led scientists to assert excitedly that vervet lingo has some of the trappings of language; their alarms seem to refer to specific objects or ideas, and their grunts are contextually dependent. Equally important is the fact that both the signal sender and the audience exercise voluntary control: Low-ranking individuals sometimes choose not to emit alarms after having noticed a predator, and group members will often ignore alarm calls given by unreliable individuals (especially juveniles). This apparent intentionality on the part of vervets argues against the notion that animals respond automatically to stimuli without any thought.

While Cheney and Seyfarth's ground-breaking work with vervets demonstrates a degree of semantics in the vocalizations of these monkeys, other scientists have investigated the subject of syntax in animal communication ("zoosyntax"). John Robinson, of the New York Zoological Society, has trained his microphones upon wedge-capped capuchin monkeys (*Cebus olivaceus*) in central Venezuela. These monkeys emit five categories of vocalizations: squaws, chirps, trills, whistles, and screams. Nearly 40 percent of the capuchin calls were part of compound "sentences"—two or more calls in a row. These compound calls seem to have a syntactic quality; chirps are frequently followed by squaws, but never vice versa; trills and whistles often lead into chirps, but rarely the reverse. Capuchin combinations seem to allow them a greater capacity for refined expression. For example, trills communicate uncertainty with another's proximity, while chirps

Vervet monkeys respond to approaching python with distinct snake alarm call, which causes other monkeys to stand on their hind legs and survey the area.

indicate a willingness for physical contact. However, a subordinate individual, desiring contact with a dominant troop member but not wanting to appear too "forward," may combine the trill and chirp to indicate its humble intentions.

John Mitani and Peter Marler of Rockefeller University have looked to gibbons, relatively small-bodied apes from Southeast Asia that fall closer to humans on the evolutionary tree than monkeys. As early morning visitors to the National Zoo (and neighboring residents of Woodley Park and Mount Pleasant) probably know, gibbons have elaborate songs audible up to two-thirds of a mile away, which they sing out each morning to announce and establish their respective territories. These versatile ballads consist of distinct elements ("notes"), which are combined to form individualized songs. Mitani and Marler recorded the songs of the agile gibbon (*Hylobates agilis*), and rearranged their notes, to compare how these gibbons react to phony and authentic songs. While their gibbon subjects approached playbacks of rearranged songs, only authentic song recordings elicited "squeaks" from males, behavior exhibited in circumstances of territorial contests between males. Apparently, the sequences of notes were crucial in conveying meaning.


Jessie Cohen/NZP

Although these various findings suggest that animal communication may employ a certain measure of syntax and semantics, few would argue from this evidence that these animals are utilizing true language. What makes language so powerful is its being "open and productive." That is, human speakers can produce sentences that have never before been uttered, but make perfect sense nonetheless. That ability has not yet been seen in the communicatory systems of any other chattering primate. However, these research projects and others show that what for years appeared as simple behavior may not be so. Perhaps there are unimaginable intricacies in animal communication that continue to escape our discovery and translation.

Ape Bilinguists?

The difficulty of decoding primate vocalizations has led some scientists to try a novel approach. Like a stereotypical American tourist abroad, researchers have decided that if you can't understand what they're saying, make them speak a language you know. Being our closest relations in the animal world—they share up to 98 percent of our DNA—and having large brains relative to other primates, great apes (chimpanzees, bonobos, gorillas, and orang utans) have been the prime focus of scientists interested in exploring the limits of animal language.

Originally, researchers thought they might be able to teach some unsuspecting apes spoken language. The most successful attempt was made in the 1950s by Cathy and Keith Hayes of the Yerkes Laboratory of Primate Biology in Atlanta. However, after several years of having her lips pulled around and her mouth squished and rearranged, their juvenile chimp, Vicki, could only muster a few words ("Mama," "Papa," "cup," and "up").

Left: Capuchin monkey at Hato Masaguaral, Venezuela, giving alarm call to photographer. Capuchin calls employ a degree of consistent "word" ordering.
Above: Siamang gibbon "singing" at the National Zoo.

Chimps and other non-human primates simply don't seem to have the necessary anatomical apparati to produce human speech (see sidebar on page 12).

However, this failure did not deter others from seeking alternate strategies to teach apes language. Two psychologists from the University of Nevada, Beatrix and Allen Gardner, in 1966 became the first researchers to start teaching chimps sign language. Their first student, Washoe, has since been transferred to the tutelage of Roger and Deborah Fouts of Central Washington University. Washoe, nearing age 30, has now used more than 1,000 taught signs in American Sign Language ("Ameslan"), and since instruction of new signs stopped in 1970, she has learned many more by her own observation. Washoe has mastered more than 200 of these signs under the Fouts' "reliable" criteria; a sign is reliable if three different observers see a chimp use a given sign in the correct context on each of fifteen consecutive days.

April Ottey

Washoe has surprised the Gardners and Foutses, and the scientific world, not only by learning hundreds of words, and effectively using them in complex "sentences," but by doing this usually without prompting, in a way eerily similar to the way we ourselves use language. Even with such an extensive vocabulary, Washoe occasionally finds the words she knows lacking, and will simply invent new words when she doesn't know an appropriate one. Such innovations include labeling a fur coat as "hair coat" and a candy bar as "candy banana." A peer chimp, Lucy, came up with "cry hurt food" when she didn't know the word for radish.

According to Roger Fouts, Washoe can communicate empathy and sorrow. She signs "hurt" and "sorry" in addition to offering physical comfort when others seem upset. "It shouldn't come as a surprise," says Fouts, "that apes have emotions." Chimpanzees and other apes show significant development of the limbic region of the brain, the area thought to control emotional responses. It would be bizarre if other animals didn't have emotions, Fouts adds.

However, we shouldn't expect chimps to communicate all of their emotions through semantic language; we humans certainly don't. Gesture, expression, tone, and other non-semantic features often communicate much more than just words alone. In the wild, Fouts suggests, chimps may take these subtler forms of "language" to the extreme. When other chimps fail to respond to Washoe's signed pleas, she knows to resort to physical communication. Once Washoe spotted a snake near a fellow chimp. She frantically signed "Come hug, come hug" to the chimp, but to no avail. Washoe finally rushed to her friend's side, and led the chimp away from danger by hand.

The lab chimps also are able to express another area of their psyche: their curiosity and inquisitiveness. While Washoe only rarely asks questions using proper interrogative pronoun signs (what, where, etc.), she indicates questioning by gestural signals, such as raising her eyebrows, and holding the sign in its position for a long time. This usage is not improper; many deaf humans use similar gestures to make signed sentences into questions.

Left: Siamangs, like other species of gibbon, have morning songs which establish their territories. Above: Washoe the chimpanzee, with Roger and Deborah Fouts looking on.

Chipping Away...

For centuries, the use of tools was believed to separate humanity from the animals. However, in the 1960s, Jane Goodall discovered that wild chimps manipulate branches and stems for use in getting honey out of hives and termites out of their mounds. Other discoveries of tool use by animals soon followed.

Rose A. Sevcik

Chimps also carry rocks around, which they use to crack open nuts. Orangs hold large leaves over themselves to protect them from sun or rain, throw sticks at humans in self-defense, and chew up mouthfuls of leaves to make sponges to soak up rainwater. Even sea otters use tools; they have been witnessed using rocks as anvils against which they smash open mollusk shells for meat.

If humans aren't alone in tool use, what else makes humans special? Some have argued that humans are unique because we use tools to *make* tools (another step in the cognitive ladder). Hominid fossils, dated as far back as two and a half million years, have been found associated with stone "flakes," sharp shards of rock that may have been used to cut apart animal carcasses. Flakes are formed by smashing one rock onto another. Making sharp flakes is not as easy as it might seem. In addition to generating enough force, the angle of the blow and its position on the rock are crucial.

Stone-tool expert Nick Toth, an anthropologist renowned for carrying rocks with him in his briefcase wherever he goes, wanted to know whether apes could create the same types of tools early human ancestors fashioned from stone. Toth and Sue Savage-Rumbaugh, who has studied the bonobo Kanzi's use of sign language, created a "tool station," consisting of various rocks and a box containing food, secured with a thick rope. In front of Kanzi, Toth banged rocks together, in a very precise manner, to form rock flakes sharp enough to cut rope. Toth then used the best flakes to cut the rope to get a treat for himself. Without any active tutoring, Kanzi learned the importance of selecting the sharpest rocks, and then on his own began trying to make sharp flakes, imitating Toth's methods.

At one point, a frustrated Kanzi handed the stones to Savage-Rumbaugh, in an appeal for her to make the flakes for him. Refused this request, Kanzi seemed to reflect for a few moments, and then stood up and threw the stone against the hard floor, shattering it into shards. He had overcome the problem with a novel solution. The scientists then thought to put in a soft carpet to prevent this from happening again. Once again, Kanzi outwitted them. He pulled up a corner of the carpeting, revealing the hard floor, and smashed the rock against it.

On one other occasion, while working with the tools outside, Kanzi came up with yet another novel approach: throwing the rock against a large boulder to break it apart. Thus, Kanzi came up with new solutions three times in his quest to form the proper tool for the task.

In addition to his invented techniques, Kanzi has been able to form flakes in the conventional manner employed by Toth. Yet, given the choice, Kanzi will select and use one of Toth's creations over one of his own. The bonobo has been observed running his fingers along the edges of Toth's flakes, apparently impressed by his workmanship. Toth's flakes simply are bigger and sharper—and therefore more useful—than the ape's. Despite being much stronger than an average human, Kanzi appears unwilling to use all of his force. Perhaps he's afraid of striking the hand he uses to hold the stone in place. Lacking the manual dexterity of humans, Kanzi also may not be able to grip stones as tightly as we can.

Nonetheless, Savage-Rumbaugh emphasizes that it is the process, not the actual end product, that is the most important component of the bonobo's use of stone tools. Kanzi has demonstrated a clear understanding of the concept of using one tool (a rock) to form another tool (a flake). Another piece of the perceived pillar of human uniqueness seems to have been chipped away.

—Alex Hawes

Left: The bonobo, Kanzi, bangs rocks together in an attempt to create sharp stone "flakes."
Below: Kanzi holds a rock flake in his mouth, before using it to open a box containing food.

Rose A. Sevcik

Perhaps the most impressive use of Ameslan by the chimps, according to Fouts, is their use of "private signing." Hidden cameras have recorded the chimpanzees signing things to themselves, even in instances of imaginary play. On one occasion, a juvenile chimp, Loulis, grabbed Washoe's magazine and ran off. Washoe then signed to herself, "Bad, bad, bad!" Fouts notes that chimps will occasionally sign to themselves "Gotta be quiet." Such uses counter arguments that apes only use learned language when "cued" by human trainers, and only for some sort of reward.

Washoe and her companions have fulfilled another requirement of language—that of teaching and learning. The young chimp Loulis learned to use Ameslan by observing others, and from others (especially Washoe) molding his hands to form proper signs. Loulis even abides by many of the grammatical rules of Ameslan, without any formal instruction. However, before proclaiming true language use by Washoe and Company, we mustn't forget the sine qua non of language: syntax. Fouts states that Washoe does know certain (but not all) fundamental rules of syntax, such as the difference between "Roger tickle Washoe" and "Washoe tickle Roger." Imperfect syntax should not negate the importance of this and other ape language studies though. As Fouts argues, language in apes is not black and white; we should strive instead to understand the *degree* to which apes use language, both in the lab and in the wild.

Certain researchers have looked beyond sign language as the lingua franca between humans and chimps. Georgia State's Duane Rumbaugh and Sue Savage-Rumbaugh, originally of the Yerkes Lab in Atlanta, have devised an elaborate automated machine that parcels out goodies to chimps, and shows them slides and video tapes. To operate the machine, and ask it for treats, chimps punch "lexigrams" (symbols composed of various shapes and lines) on a large keyboard. Each lexigram represents a different word. Two closely related species, chimpanzees (*Pan troglodytes*) and, later, bonobos, or "pygmy" chimps (*Pan paniscus*), have been pupils of this invented language, which lab workers have labelled "Yerkish."

Two-way communication is possible through the machine. In fact, two chimps, Sherman and Austin, learned to use the machine to ask each other for tools the other possessed in order to open containers of food. Sherman and Austin, and the first student of "Yerkish," Lana, were tested for comprehension of categories of objects. Shown food items and tools, and the lexigrams representing each one, Sherman and Austin were able to arrange new objects into the proper general categories of "food" and "tool" perfectly (except for one instance when Sherman labeled a sponge "food," probably because he occasionally nibbles on them). Poor Lana, however, had seemingly not acquired these abstract concepts.

Recently bonobos have shown particular success with Yerkish, perhaps because they forage in larger parties on average than chimpanzees, where social communication between each individual is necessary to maintain group cohesion. Instead of simply responding to questions and commands posed by the machine, bonobos are now using their new language to express themselves spontaneously. Kanzi, a male bonobo, learned Yerkish entirely by watching human trainers and his own mother use the system. Now Kanzi can understand, Savage-Rumbaugh estimates, between two and three thousand spoken English words, as well as all of the 250-plus keys on the Yerkish keyboard. Kanzi is apparently trilingual, if you count bonobish.

Kanzi and friends seem to understand many of the complexities of human language. When presented with a tomato, a bonobo will respond to the command "Go and get the tomato that is inside the microwave" by correctly retrieving the distant tomato rather than the one that is visible. Bonobos use Yerkish to discuss things they will do hours in the fu-

ture, as well as things they did yesterday. They know, for example, the word "later," and use this term to convey activities they plan on doing at another time.

They also comprehend the possibility of deceit in language. One bonobo was sitting with Savage-Rumbaugh and another trainer, Liz, when Savage-Rumbaugh placed some M&Ms in a bag, in plain view of the other two. When Liz left the room, Savage-Rumbaugh took out the M&Ms and replaced them with a bug. The bonobo signalled "bad" in light of her trainer's chicanery. When Liz came back and looked through the bag for the candy, Savage-Rumbaugh asked the bonobo what Liz was looking for. It signalled "M&M," despite the fact that they were not in the bag. Human children up to the age of four or five would likely answer instead "bug," not being able to separate the knowledge of the duped assistant from their own knowledge.

As for the dreaded "s" word—syntax—the chimps taught Yerkish apparently understand spoken English syntax perfectly well (as the tomato example shows). In his signed "utterances," Kanzi employs what Savage-Rumbaugh labels "proto-grammar." Like Washoe, he seems to have rules he has worked out on his own. However, Savage-Rumbaugh maintains that the ability to communicate complex ideas and messages, rather than the specific order of the messages' component parts, is what indicates a profound comprehension of language use. It is "extraordinarily anthropocentric," says Savage-Rumbaugh, to expect apes to use language in exactly the same way we do.

One initial skeptic of these studies was Herb Terrace of Columbia University. He trained a young chimp, Nim, in Ameslan. He then performed an exhaustive study of Nim's use of word order. Nim rarely used any regular pattern in combining words, and when he did, he seemed to be merely copying the previous statement of the trainer. Most researchers in primate language have not taken this critique to heart; first of all, Nim was only a juvenile, and even juvenile human children have trouble with word order. Also, Nim had dozens of different human trainers; this instability may have impeded his progress in acquiring proper grammar.

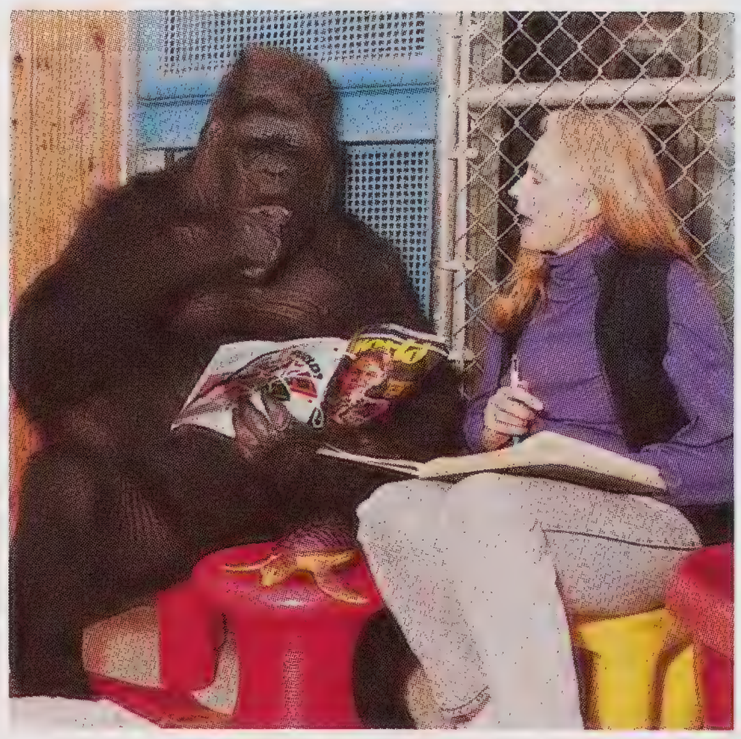
Moreover, it is the way chimpanzees use language as a whole, rather than their use of specific syntactic relations, that most impresses scientists. Their ability to manipulate language for the purposes of deception may most effectively prove that they are using language in thoughtful ways. Anecdotal evidence from field studies has demonstrated duplicity in primate behavior in the wild. Jane Goodall has commented on numerous instances when individual chimps, foraging in a larger group, will come across a source of food, not give a food-location call, and later circle back when the others are out of sight to eat it up.

Working with language-trained chimps, David Premack, recently retired from the University of Pennsylvania, performed an experiment in which chimps were instructed to indicate to two different trainers where food was hidden in their enclosures. One trainer would always share the food with the chimps, while the other one would always eat all the food himself. Gradually, the chimps learned to withhold accurate information from the "greedy" trainer, and would often mislead him or her with their signals. Roger Fouts notes that, while discerning chimp intentions is essentially impossible (as it is with humans), chimps do demonstrate as wide a spectrum of deceit as is found in human behavior. (Perhaps they will soon be given roles on "Melrose Place.")

"Fireworks Child"

Ever since King Kong scaled the Empire State Building, the public's view of gorillas has been unfairly tainted. But gorillas (*Gorilla gorilla*) are not the monsters we make them out

to be—they are, rather, "peace-loving vegetarians" according to Francine Patterson of the Woodside, California-based Gorilla Foundation. Patterson's acquisition of a baby gorilla named Hanabi-Ko (Japanese for "fireworks child"), or "Koko" for short, has done much to turn back the tide of gorilla bad press. Koko has since used American Sign Language to show the world her sensitive, humorous, and often stubborn personality.



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Patterson has had a hard time keeping track of Koko's vocabulary—the gorilla has used many hundreds of different signs (matching and then surpassing the chimps' performance) with varying frequency since Project Koko's inception in 1972. Patterson stresses, however, that having a huge vocabulary isn't all that necessary; fluent human Ameslan users can get by easily with 500 to 1,000 signs, compounded by gesture and expression. An English dictionary may have as many as 200,000 words, while an Ameslan version has only 2,000. English may be unnecessarily wordy, verbose, prolix...(you get the point). A study of graduate-level essays at Stanford University found that students used on average only 300 different words per essay—and graduate students are renowned for being excessively prolix.

Although getting Koko to use her knowledge of sign-language has proven difficult at times, her stubborness has also provided insight into her grasp of Ameslan. Once when Patterson was drilling Koko on anatomical terminology, the gorilla signed, "Think eye ear eye nose boring." One undoubtedly thinks of human schoolchildren when reading that statement.

Like Washoe, Koko has created new terms for unnamed objects: "elephant baby" for a Pinnochio doll; "bottle match" for a cigarette lighter; and "eye hat" for a mask, to name a few. Koko has displayed her comprehension of the representative nature of words additionally through "overgeneralizations"—a term for when one learned sign takes on new meanings. Patterson notes that, having learned "straw," Koko applied this sign as a name for plastic tubes, hoses, and even cigarettes. "Tree" similarly came to signify asparagus and scallions.

Responding to spoken English as well as Ameslan, Koko also can understand the relationship between spoken and signed words. This link is most evident in her interest in rhyme. Patterson reports that Koko can use Ameslan signs to "rhyme" words that would rhyme if spoken aloud in English. She once signed "flower stink fruit pink," and when Patterson remarked about her rhyme, Koko continued, "Love meat sweet." Koko's a poet, and apparently she knows it.

Koko also is a comedian, according to Patterson. One target of her humor, and ridicule, is a researcher named Ron. When asked, "Who Ron," Koko responded, "Stupid devil."

Top: The studious ape: Francine Patterson watches as Koko the gorilla "reads" a magazine. Below: Koko gives Patterson the sign for "sip."

Mindful of Thought

Throughout the course of history, humans have held themselves up on a cognitive pedestal over the animal kingdom. Birds may be able to fly, elephants may be able to uproot large trees, but we humans, at least, can think. In recent years, though, scientists have provided insight into animal minds by studying how their behavior can indicate complex thought. The questions of if and how animals think provoke heated psychological, biological, and philosophical debate. A new exhibit at the National Zoo, called Think Tank, tackles the issue of animal cognition to a degree not seen before in any zoo or museum.

Jessie Cohen/NZP

In many ways, Think Tank is a unique endeavor for a zoo. Not simply a display of an animal species, this exhibit "will allow visitors to explore the concept of thinking and, in the process, gain an understanding of the way scientists investigate thinking in animals," according to National Zoo Director Michael Robinson. The Zoo has remodeled the 90-year-old former Monkey House to create not only enclosures for two species of primates—orang utans and Sulawesi macaques—but a setting where zoogoers can witness scientific investigation. The exhibit challenges those who enter to "think hard about thinking."

As the visitor passes through the entrance, he or she encounters a dozen video screens, which show images of various animals exhibiting behavior typical of their species—a beaver building a dam, a spider constructing a web, and so on. Each screen then asks the visitor questions such as "Is this animal thinking?" and "How would you know?" As the visitor continues, an interactive exhibit area offers more specific evidence of animals' complex behavior, and poses more questions about these examples' significance.

Zoogoers journey into the center of the animal brain, literally. A display outlines the anatomy of the brain and the role of its component parts. The exhibit asks people to compare the sizes of different species' brains. You may be surprised to learn that if a squirrel weighed as much as an average human, its brain would be about 50 percent larger than that of a person. However, the display explains, not only the size of the whole brain, but the size of certain individual parts, matters in cognitive processes.

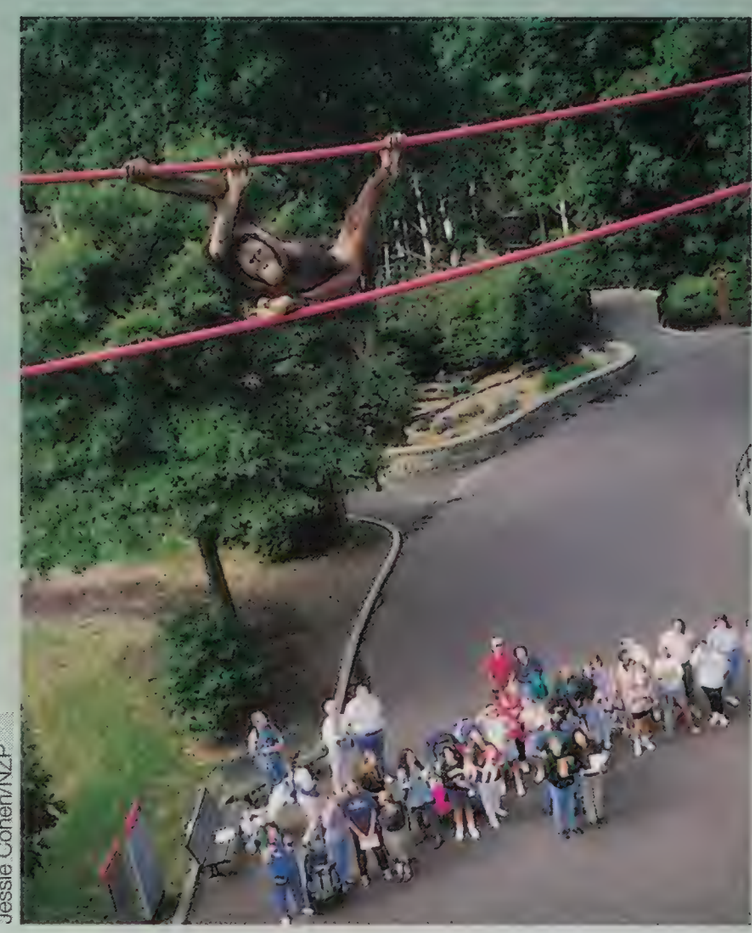
Think Tank graphic displays emphasize three factors crucial to establishing the existence of thought: image, intention, and flexibility. The exhibit provides an example to illustrate what these ideas mean: A visitor comes to the Zoo and, upon arrival, it begins to rain. Opening an umbrella, he or she finds that it's broken, and then decides to buy a poncho. "Image" is defined as a mental representation of something not present—in this case, the thought of shelter, or the idea of buying a poncho. "Intention" pertains to an individual having a goal in mind—wanting to buy a poncho to stay dry, for example. "Flexibility" relates to being able to create a "Plan B" (buying a poncho) if "Plan A" (using one's umbrella) doesn't work. Evidence of each of these three points must be met, according to Think Tank researchers, for thought to be demonstrated.

Using this theoretical framework, the displays focus upon three specific areas in which scientists have traditionally explored human and animal thinking: tool use, language, and social interaction. Tool use was once thought to be unique to humans. However, some animals have shown the ability to manipulate objects to attain certain goals. Chimpanzees use sticks, vines, and bark to "fish" termites out of holes, and they use (and even carry around) particular rocks for cracking nuts. In Think Tank, zoogoers encounter a display of a hermit crab group. Hermit crabs must find new shells periodically as they grow, and select ones that serve to protect them best. Are hermit crab shells "tools?" Would you consider hermit crabs to be thinking when selecting new shells?

Exhibits also challenge people to consider the importance of language communication as an indicator of cognition. Researchers working in Think Tank inform visitors regularly on the progress of the Orang utan Language Project (discussed in the main article), and, in the future, visitors may be able to communicate with the orangs through this language system.

Many people might not associate the third and final subject, society, with thinking. Social intelligence, however, can be expressed through alliance-building, cooperation, deception, and other ways individuals manipulate fellow group members for their own benefit. A troop of Sulawesi macaques, housed in Think Tank, provides onlookers with examples of such social complexity.

Sulawesi macaques (*Macaca nigra*) are mid-sized monkeys found in the wild only on the Indonesian island of Sulawesi. Jessica Hadley is studying the transmission of culture in the Zoo's macaque troop. Visitors can join Hadley in watching how new items introduced to the macaques are used by certain individuals, and how others may imitate fellow group members' novel behavior. Zoogoers can also observe the social hierarchy of these primates, and test their ability to decipher the macaques' dominance relationships. A display of field journals from Zoo primatologist Wolfgang Dittus' 26 years of research on the social behavior of toque macaques (*Macaca sinica*) in Sri Lanka complement the research going on in the Sulawesi macaque habitat.



Jessie Cohen/NZP

Social behavior is also explored in an exhibit of leaf-cutter ants. Leaf-cutter ants in the wild live in colonies of up to several million members, in a complex social hierarchy. Able to defoliate a tree in a few hours, a leaf-cutter ant colony uses harvested leaves in their underground lairs to "farm" fungus, upon which they subsist. A leaf-cutter colony on display at Think Tank will startle zoogoers with the insects'

complex behavior and communal efforts. But does this behavior demonstrate thinking?

The Think Tank founders hope to spark interest in the study of animal behavior by allowing zoogoers an opportunity to participate actively in studies normally

Jessie Cohen/NZP

done only by scientists. Studies of animal cognition, both outlined in exhibit displays and accessible to the general public first-hand through the orang utan and macaque projects, hopefully will cause visitors to come away from Think Tank with a new-found appreciation of animal intelligence. The exhibit stresses the complexities underlying our natural world, and seeks to educate the public about these issues—achieving two of Zoo Director Michael Robinson's goals in developing the National Zoo into a "BioPark."

Benjamin Beck, the Think Tank's project leader, adds, "There is a great deal of understanding of animals to be gained from a visit to Think Tank, but I would consider the exhibit a success if visitors leave only with a better understanding of the way scientists do their work." Researchers involved with this new exhibit also hope that Think Tank will cause zoogoers not only to respect animals' cognitive abilities, but realize the worth in pursuing further study of them, and the need to save them from extinction.

—Alex Hawes

Above left: The Think Tank building, built in 1904 to serve as the Small Mammal House, and more recently used as the Monkey House, is the oldest in use at the Zoo. The original architects, James Marshall and Joseph Hornblower, also designed the National Museum of Natural History. Left: Orang utans cross directly overhead Zoo visitors when traversing the O-line to Think Tank. Above: Sulawesi macaques—subjects of investigation into social behavior and intelligence at Think Tank.

When later asked "What is funny?" Koko demonstrated her mastery of sarcasm: She signed "Koko love Ron" and gave him a kiss, grinning the whole time.

This gorilla has also mastered a less honorable technique: lying. Once, when playing roughly, Koko nipped a trainer, and then signed "Not teeth." Reprimanded by the trainer, "Koko you lied," Koko meekly admitted "Bad again Koko." On another occasion, a trainer discovered Koko eating a crayon. When the trainer cried, "You're eating crayon!" Koko made the sign for "lip" and pretended to be applying lipstick.

Readers may recall a traumatic episode in Koko's life, when her pet kitten, All Ball, escaped and was run over by a car. Koko openly expressed her grief by signing "Sad" repeatedly. Moreover, she seems to understand concepts of life and death surprisingly well. When asked where gorillas come from, she pointed to her abdomen, and when asked when gorillas die, she signed "Trouble old." Where do they go once dead?: "Comfortable hole." It shouldn't surprise you too much now that, on various intelligence tests given to Koko over the years, Patterson reports that Koko has recorded I.Q. scores from 70 to 95 (not too far below the human average of 100), and that's including deductions for answering "flower" for "What is good to eat?" and "tree" for "Where do you go to sleep?"

A Fourth Party is Heard From...

It was only a matter of time before scientists gave the fourth and final great ape, the orang utan (*Pongo pygmaeus*), its fair shot at language mastery. Orangs actually have fared as well or better than chimps and gorillas on various cognitive tests. The first attempt to teach an orang a human language was made by Lyn Miles, of the University of Tennessee. Miles taught Ameslan to a male orang named Chantek. Learning his first word in less than a month, Chantek went on to learn and use more than 150 signs, and can form simple sentences. Chantek too can create novel words, labeling contact lens solution "eye drink." Deceit? Chantek shows that too—lying an average of three times a week, calculates Miles.

Chantek has also invented some of his own grammatical rules. If referring to an action in conjunction with an object present ("play ball" for example), Chantek places the action first, whereas if the object is not visible, he places the object sign ahead of the verb ("Ball, play").

In the wild, orang utans lead mostly solitary lives. Stable groups are formed only between a female and her young. This apparent lack of sociality has caused scientists to wonder whether the orangs' perceived language ability really derives from social interactions between individuals, as has been theorized for other apes. Miles suggests another

The orang Chantek signs "chase," hoping the Kermit puppet will chase him. Courtesy of Project Chantek, University of Tennessee.

possibility, "the extractive foraging origin." Orang utans are fruit-eaters, and because of this food source's scarcity, they must be able to remember over the course of several years the location of various reliable fruiting trees within a vast territory, and routes between such sources.

Another cognitive capability orangs show is expertise with tools—the most complex tool use witnessed in captivity by a great ape. Chantek, observes Miles, can put together a chain of at least 22 different tool tasks to attain a goal (for example, using a key to open a box to get wire cutters to open a cage to get a hammer, for up to 22 commands). It was only recently that researchers discovered intricate tool ability by orangs in the wild. The general cognitive ability of orangs, seen in their foraging strategies and their tool use, may then underlie their capacity to learn human language.

We can't completely write off the social living theory though, cautions Miles. "Orangs may have been more social in the not-too-distant past, and have only recently resorted to solitary living." Why then would they have "gone solo?" Environmental degradation, Miles theorizes. Before human disturbance drove orang utans from most of their original habitat across southeast Asia into only a few pockets of Borneo and Sumatra, they may have lived in social groups more similar to those of chimps and gorillas. However, with a less than ideal environment, group living may have gradually disappeared, as competition within groups prevented individuals from finding enough food for themselves to survive.

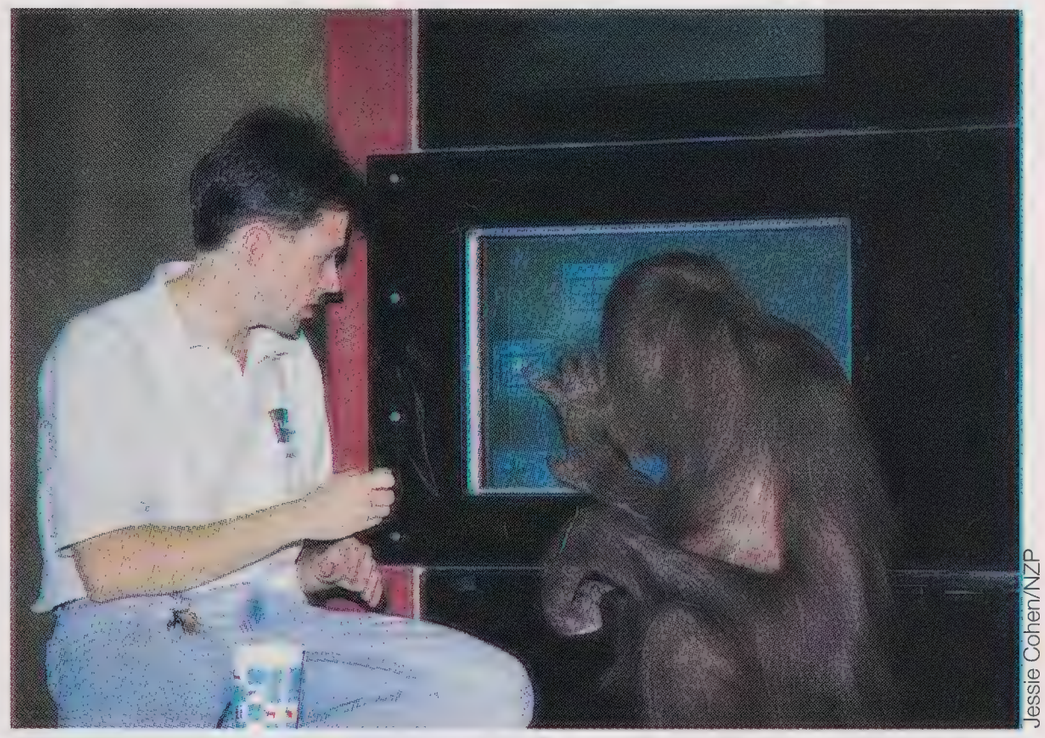
Towers to Babble

Politicians are no longer the only ones struggling to communicate their ideas inside the Beltway these days. Orang utans at the National Zoo have now entered the fray in the heated debate over apes' language capabilities. Under NZP biologist Rob Shumaker, the Orang utan Language Project (OLP), three years in the making, was unveiled October 27 at the opening of the Zoo's newest exhibit, Think Tank (see sidebar, page 22). National Zoo orangs cross overhead between the Great Ape House and the new Think Tank building via tall towers and long vinyl-covered cables ("the O-line") to study their new language. The OLP picks up where the other investigations have left off: It not only involves teaching orangs a language composed of abstract symbols, but focuses on how their knowledge of this language will be transferred, and possibly taught, to other orangs not instructed by trainers.

The OLP's language of choice is a computer-based form, designed by Shumaker, and centered on abstract symbols that each represent a word (see diagram on page 28 for examples). Words are broken down into seven categories: food, activities (verbs), adjectives, non-food objects, human names, orang names, and numbers. Each category has a distinct exterior shape (such as diamond, circle, rectangle) and words within each category are specified by interior markings. For example, food items are characterized by rectangles: The symbol for "apple" is a rectangle with a straight line and a dot in the center, while "banana" is conveyed by a rectangle with a horizontal wavy line. Verb activities, however, are all defined by diamond shapes forming the symbols' exterior. Seventy words have been developed in the system so far, of which the orangs have only been shown a few. However, there is room for an infinite amount of further additions.

Left: Junior, a 30–year–old male orang utan, appears to have something to say. Apes, however, lack the proper anatomy to produce spoken words.

The orangs, in their "smart room" enclosure, have two video monitors—the "response monitor," a touch-frame screen, and the "stimulus monitor," over which visuals are broadcast. Among other possibilities, the apes are posed questions via the stimulus monitor, and they respond by pointing to possible choices on the response monitor. Stimuli and responses, however, can take all forms; a photograph, painting, or iconic drawing of an apple may appear, and the subject tries to match that image with the corresponding "apple" symbol from a choice of several on the response screen. Conversely, the stimulus screen may show a language symbol signifying "apple," and the orang will pick from photographs of fruit and/or other objects displayed on the response screen, or even displayed physically by a trainer. From there, lessons can get more and more complex depending on the progress of the orangs. Just as the questions posed will ultimately be limitless, so too will be the orang utans' possible responses. We can only wait and see, literally, what they will have to say.


Jessie Cohen/NZP

Most intriguing from a research point of view is the OLP's focus on observational learning. Of the three pairs of orangs involved (Azy and Tucker; Bonnie and Kiko; Indah and Iris), only the dominant (and usually older) individual in each pair is actively instructed in the language by trainers. The subordinate ones can only pick up on the symbols and the use of the language system through observation, or through their partners' teachings. However, on a regular basis each individual is tested on this knowledge and use of the language. Researchers quantify and compare the success of instructed and non-instructed individuals. This study promises to offer us interesting clues into how tool use, communication, and other behavior may be transmitted culturally between primates in the wild.

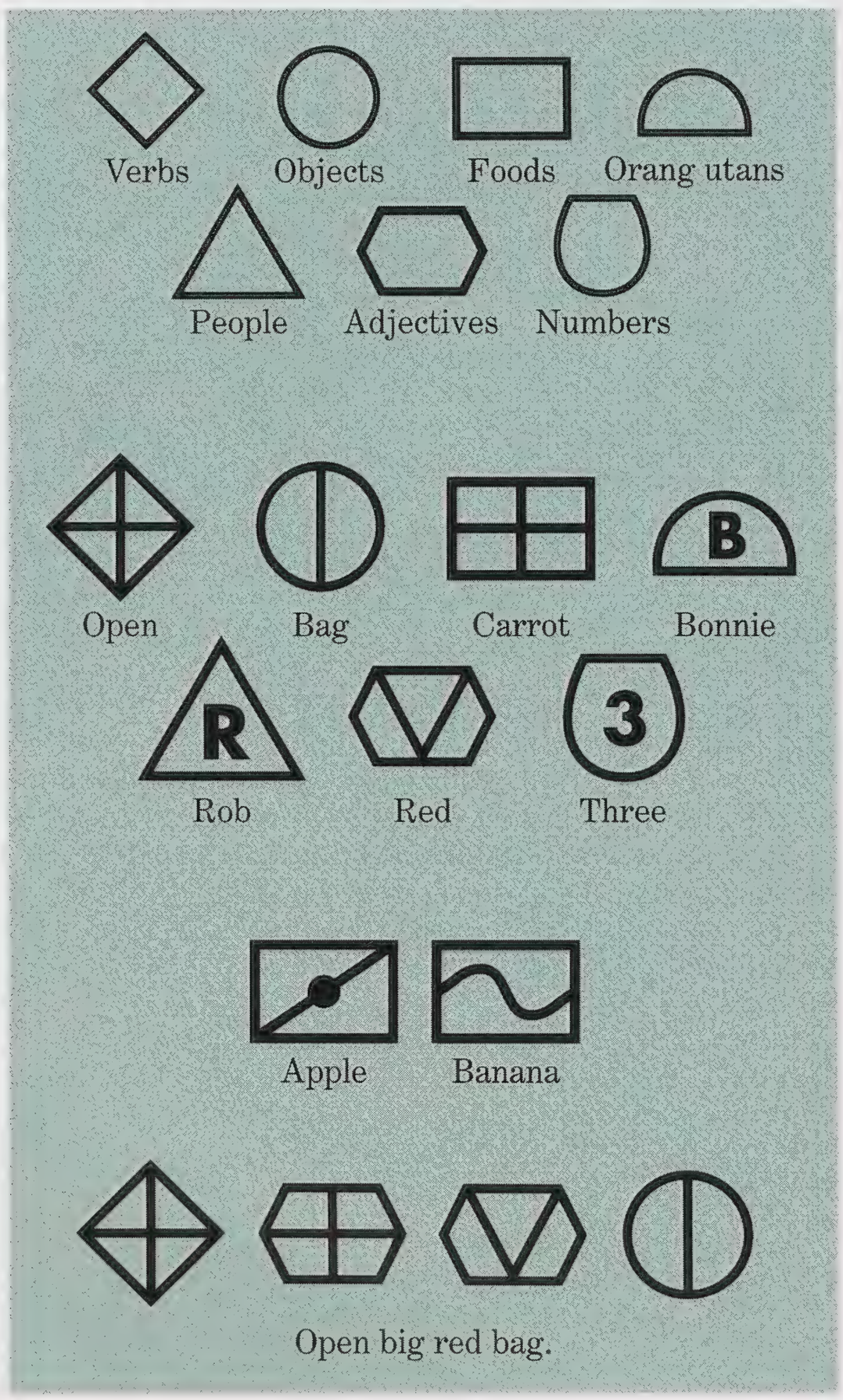
Perhaps the most exciting part of all this, from a zoogoer's perspective, is that the action takes place in plain view of the visiting public. Three mounted monitors display the same video "feed" that the orang is working with, as well as live footage from cameras focused on different areas of the orangs' enclosures, and on the O-line. Both orang students and human visitors can watch the action of orangs frolicking elsewhere whenever either gets bored.

Shumaker strongly emphasizes that the machine is simply a means through which the orangs can communicate. Shumaker himself controls, through a computer hooked into the language program, the questions posed to the apes. He hopes that, when the orangs become more proficient with the use of the system, he will be able to build upon the intricate relationships he already has with his primate pupils. Shumaker mentions one of the project's hopes and goals down the road: to allow Zoo visitors to sit down in front of the computer, and not only try their hand at the increasingly difficult puzzles challenging the orangs, but in fact to use the language system to communicate directly with the orangs themselves. That might represent the ultimate experience a zoo can offer.

Left: Iris demonstrates a play face. Primates rely on non–vocal gesture and expression for much of their communication.
Above: Rob Shumaker and Indah communicate using the OLP language at Think Tank.

Planet of the Apes (Too)

"We are looking at the ability of apes to use abstract symbols in a concrete way," explains Shumaker. The fact that apes possess the ability to think abstractly may represent the most significant finding of the various ape language projects. While orang utans and other primates may not have developed a system of communication in the wild complex enough to be labeled as a language, they may, however, be thinking about their social and physical world in abstract ways. As Shumaker cautions, we should not be overly obsessive about the specific performances of apes learning new languages, for the projects are only "applying [ape] communication in a way more meaningful to us."



Linguists have been quick to deny any language ability in wild or tutored apes, shouting cries of "Syntax!" and "Semantics!" left and right. They have ignored, however, the proven intricacy and power of non-verbal communication, such as gesture and expression, in humans as well as in our primate brethren. Although there may be a gap between the structured way we use language and the way primates combine subtle non-vocal cues with seemingly representative signals, this divide has been all but bridged by great ape "students" once given the chance to learn. Perhaps the gap between wild primates and ourselves does not reflect primate stupidity, but "just gaps in [researchers'] scholarship," as Roger Fouts suggests. One thing that is certain is that these studies have caused us, as Lyn Miles puts it, "to wonder how far boundaries of human uniqueness really go."

Miles, who says she has always been interested in the possibility of life on other planets, adds that "There is extraterrestrial intelligence—right here on Earth, in the orang utans." And the gorillas, and chimps, and bonobos, and who knows how many other species. "The most important point of all this," she continues, "is that we're not alone. We share this planet with other intelligent animals." Unfortunately, as mankind threatens the habitat and ultimate survival of these brilliant creatures, we may never understand the full complexity and potential of their communication—and their minds. Hopefully, humans will learn to show the animal world what it has clearly shown us: thoughtfulness.

Alex Hawes, an intern with ZooGoer, *holds a BA degree in anthropology from Yale. He has studied the social behavior of gorillas in the Franklin Park Zoo in Boston, and of wild lemurs in southwestern Madagascar.*

Symbols used in Think Tank's OLP language.

books, naturally

For those thirsting for more information about animal communication, the ape language projects, primate behavior, or the evolution of human societies, here is a brief listing of intriguing books currently in print that we suggest (* indicates that the book is available in the Zoo Bookstore):

Animal Thinking. 1984. Donald Griffin. Harvard University Press. 237 pp. softbound, $12.95.* & *Animal Minds*. 1992. Donald Griffin. University of Chicago Press. 310 pp. softbound, $14.95.*

Griffin, one of the founding fathers of the study of animal cognition, has written two equally worthy books for those interested in this controversial subject. Fascinating evidence of complex thought in the animal kingdom, written with an academic edge, yet still quite readable. *Animal Thinking* was a landmark book of its time, and *Animal Minds* brings us up to date with more recent research and new ideas. You'll never look at your neighborhood squirrel or starling the same way again.

Animal Talk. 1992. Eugene Morton and Jake Page. Random House. 275 pp. hardbound, $22.00.*

Morton, a biologist with the National Zoo, and Page, former editor of *Natural History* and former science editor of *Smithsonian*, join forces for a cleverly written discussion of animal communication and what it may, or, more important, may not, mean. While Morton's background in ornithology provides many examples from the avian world, the authors discuss a wide variety of animal species, from elephants to bees, and from whales to monkeys.

Alex Hawes

Kanzi. 1994. Sue Savage-Rumbaugh and Roger Lewin. John Wiley & Sons, Inc. 299 pp. hardbound, $24.95.*

With Lewin's experience popularizing issues in human evolution, and Savage-Rumbaugh's years of work with the ape-language projects at the Yerkes Primate Center, *Kanzi* offers readers both incredible anecdotes about bonobo creativity and intelligence as well as the significance of these stories. The projects' overall findings are summarized. The best recent book on an ape language experiment and a rare glimpse into the mind of a bonobo.

Primate Societies. 1987. Edited by B.B. Smuts, D.L. Cheney, R.M. Seyfarth, R.W. Wrangham, and T.T. Struhsaker. University of Chicago Press. 578 pp. softbound, $32.95.

The definitive anthology covering all aspects of primate social behavior. The first section discusses taxonomic groups of primates one by one, and the social traits characteristic of each. Further chapters succinctly tackle broad topics in primatology, from reproduction to conservation. Each chapter is written by experts on the topic. Academic in bent, yet very manageable.

Language and Species. 1990. Derek Bickerton. University of Chicago Press. 297 pp. softbound, $15.95.*

In one of the few books that examines thoughtfully both animal communication and human evolution, Bickerton leads us through the steps in hominid history that allowed our ancestors, over millions of years, to bridge the gap between the relatively simple communication systems of apes and other animals and our modern human language. Bickerton shows us that language is a fundamental characteristic of who we are—and a pre-requisite of our culture—and that without it we would still be adapting to nature, rather than adapting nature to us.

The Third Chimpanzee. 1992. Jared Diamond. Harper Collins. 407 pp. hardbound, $25.00.

Diamond, a University of California at Los Angeles physiologist and part-time ornithologist, has written a fascinating exploration of the past, present, and future of the human species. The book deals with the biological roots of genocide, drug addiction, rape, and other behavior, as well as the human tendency to stand up against this baser side of our nature. Diamond concludes by imploring us to use our human wisdom and thoughtfulness to overcome the bleak future that our environmental degradation, overpopulation, and nuclear proliferation otherwise promises. A scientifically thorough, yet nobly ambitious, work by Diamond.

—*Alex Hawes*

The Area Scene

Rabbits flourish almost everywhere, making it easy to sight them in suburban areas and even possible to catch a glimpse of them hopping among the buildings of downtown Washington. The species common in this region is the eastern cottontail (*Sylvilagus floridanus*). Though its white tail is its most prominent feature, the eastern cottontail also often has a white spot on its forehead. Otherwise, its coat is mainly grayish-brown with some black. Winter is a time of reduced activity for these animals, as they find hiding places in hollow logs, stumps, and burrows made by other animals. Still, signs of their presence are evident throughout the areas that they inhabit. Giving up their more diverse summer diet in favor of woody plants, cottontails gnaw on twigs and strip tree bark. Winter snow often preserves their distinctive tracks—nearly round fore prints and more oblong rear prints. Cottontails are most active at twilight and dawn.

The Good News...

There is hope for environmental recovery following the devastating oil pollution that resulted in 1990 and 1991 from the Gulf War in Kuwait. Wild plants are growing in areas of the Kuwaiti desert that suffered moderate levels of oil contamination, and the plants apparently have clean white roots in spite of the blackened sands in which they grow. Researchers have found that microorganisms living on the roots of the plants metabolize the oil in the surrounding soil. As part of a symbiotic relationship with the plant, these microflora can gain energy from the oil while producing an environment in which the plant can survive. This natural detoxification process provides hope for the war-affected areas of Kuwait, and promises to furnish a natural means of addressing the problem of oil contamination in the future.

—*From* Nature, *July 27,* 1995.

...The Bad News

Nearly a decade after the ivory-billed woodpecker (*Campephilus principalis*) was rediscovered in Ojito de Agua, Cuba, researchers report that those birds may have represented the last of the species. Unsuccessful attempts to relocate the woodpecker in 1991 and 1993 have led many experts to believe that it has now joined a growing list of extinct bird species. The ivory-billed woodpecker has had an uncertain—almost mythical—existence throughout the twentieth century, after sporadically reported sightings reengendered belief in its continued existence. The ivory-billed woodpecker's range once included the southeastern swamp forests of the United States, though no reliable sightings have been reported from there since the 1950s.

The birds' disappearance in both Cuba and the U.S. is likely due to logging, which destroyed the primary forests where they explored dead and dying trees for wood-boring beetle larvae. Unfortunately, the political turmoil of the Cold War era prevented early attempts to monitor the woodpecker's status in Cuba, and recent efforts to save them, such as an end to logging in Ojito de Agua, probably came too late. Researchers now hope that Ojito de Agua will continue to be kept as a reserve for the diverse forms of wildlife that remain there.

—*From* Cotinga, *February* 1995.

What's in a Name?

There is little consensus on how the turkey (*Meleagris gallopavo*) received its common name. One theory attributes it to a former European misconception that the New World bird was native to Turkey. Others suggest that the bird's name comes from the Hebrew word "tukki" for "peacock," or from the bird's "turk, turk" call. A different explanation is that the name is derived from an aboriginal Indian word pronounced "furkee." In light of the upcoming Thanksgiving holiday, we probably find this final explanation the most appealing. But it is interesting to note that turkey did not become the primary feature of the Thanksgiving meal until the 1800s, and that the domestic turkeys that we purchase today are actually descendants of those originally taken from Mexico to Europe by the Spanish conquistadors. The U.S. wild turkey population has recently rebounded to numbers that may surpass those of colonial times, when Benjamin Franklin wrote that he preferred it to the bald eagle as the choice for national bird.

Urban Animal Safari

The Washington metropolitan area provides ideal habitat for a variety of wild artistic creations. These lively, if inanimate, creatures range all over the region, from our most famous public places to the most secluded private lairs. Pictured here is one of these fantastic animals. Can you track its location? (Look for the answer in the January/February issue.) *Answer to July/August Urban Animal Safari:* The dapper painted armadillo adorns a sign for the Armadillo Grill, at 8011 Woodmont Avenue in Bethesda.

—*Compiled by Kasey McCracken*

Christy Bowe

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